Canada Mortgage and Housing Corporation

Société canadienne d'hypothèques et de logement

CMHC Helping to house Canadians

TECHNOLOGY TRANSFER AND INNOVATION IN THE CANADIAN RESIDENTIAL CONSTRUCTION INDUSTRY

EXECUTIVE SUMMARY

Prepared for

Canada Mortgage and Housing Corporation

by

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TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY 1

BACKGROUND 1

ACKNOWLEDGEMENTS 1

SCOPE OF THE STUDY 2

STUDY OBJECTIVES 2

THE STRUCTURAL ENVIRONMENT 3

CHARACTERISTICS OF THE INDUSTRY 3

CHARACTERISTICS OF THE MARKET 4

THE POLITICAL/INSTITUTIONAL ENVIRONMENT 5

DIFFUSION 6
- The Diffusion Process 6
- Communications and Diffusion 6

TYPES OF INNOVATIONS 7
- Fundamental Innovations 7
- Adaptive Innovations 7
- Functional Innovations 8

BARRIERS AND DIFFUSION ACCELERATORS 11
- Relative Advantage 11
- Compatibility 11
- Communicability 11
- Complexity 12
- Trialability 12
- Risk 12
- Distributor Strength 13
- Trade Resistance 13
- Regulatory Resistance 13
- Liability 14
- Supporting Innovations 14
- Government Support 14
- Consumer Resistance 15

Page

THE PACE OF INNOVATION 15

OBSERVATIONS AND CONCLUSIONS ON DIFFUSION OF INNOVATIONS IN THE LRRCI 21

RECOMMENDATIONS 23

EXECUTIVE SUMMARY

BACKGROUND

In early meetings of the National Housing Research Committee, the topic of technology transfer emerged as a key priority among participants in the housing sector. As a result, the Canada Mortgage and Housing Corporation (CMHC) commissioned James F. Hickling Management Consultants to undertake a study of the Low–Rise Residential Construction Industry (LRRCI) in order to examine the process of technology transfer and diffusion in this industry. Empirical evidence had indicated that innovations in terms of building materials and techniques, and in marketing and associated services, are not adopted quickly and do not spread widely. CMHC sought, through the identification of factors which drive and/or constrain the process of technology transfer and diffusion, to identify measures which the government and industry can utilize in encouraging the diffusion and adoption of technology in the residential construction industry.

The nature of the low–rise residential construction industry, itself, was believed to be one of the major reasons why innovations are not adopted as quickly and widely as in other industries.

Seventy in–depth interviews were conducted with manufacturers, distributors, builders, architects, tradespeople, trade associations and government experts. The entire effort was preceded and supported by an extensive review of the literature.

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SCOPE OF THE STUDY

The low–rise residential construction industry is the sum of all of the activities performed by contractors and others engaged in the assembly of housing units, as well as engineers and design professionals, manufacturers of components, materials and equipment, those involved in the research and development of related products and processes, those who regulate the industry and the people that purchase, own or use the houses that it produces. This study of the process of technology transfer and diffusion has focused on the path taken by the innovation after it has left the realm of the materials, equipment and product suppliers, who tend to be large companies such as Domtar, Dow, and Alcan with strong internal R & D programs. It recognizes that what happens at that earlier stage has little relationship to the way in which technology transfer and diffusion occur in the low–rise residential construction industry. Suppliers, however, have been studied for their role as sources of product innovations and as diffusion accelerators.

STUDY OBJECTIVES

The objectives of this project were to:

- describe the workings of the technology diffusion process in residential construction to enable those engaged in research and development in the field to structure their outputs in the optimum fashion, target them where they will have the most effect and generally frame their dissemination policy in an effective way,

- identify how circumstances or configurations of events influence the pace of adoption of new residential construction technology and how the technology diffusion process may differ depending on what is the driving force in the process at any point in time,

- identify the impediments to technology diffusion in residential construction, paving the way for actions which will eliminate these impediments, both on the part of governments and the industry,

- identify the factors conducive to technology diffusion to enable government and industry strategies to be framed in such a way as to reinforce these factors, and

- identify ways in which both government and industry can work to encourage the effective dissemination and adoption of new technologies in the residential construction industry.

THE STRUCTURAL ENVIRONMENT

Technology development and diffusion does not occur in a vacuum; it is dictated by the structure and diffusion permeability of the industry and market environment and by the political environment and its effects on such important institutions as CMHC, NRC, EMR and others.

CHARACTERISTICS OF THE INDUSTRY

The Low Rise Residential Construction Industry is characterized by:

- A large number of small builders and a small number of large builders. In certain areas, large builders are moving out of the Low–Rise Residential Construction Industry and into the High Rise/Commercial Construction segment of the industry, increasing even more the already high proportion of small builders.

- The discontinuity factor. The industry is adversely affected by time, vertical and lateral discontinuities. More than one third of firms have been in business for less than five years. It is also one of the least vertically–integrated industries. Finally, it is also characterized by "lateral" discontinuity as most of the work is subcontracted to independent sub–trades.

- The low formal level of education prevalent in many sub–sectors.

- A products and materials supply system which is geared to high volume, low mark–ups, a situation which works against high margin, low volume, and high value service innovations.

- A primary incentive to reduce costs to the builder.

- A descriptive rather than performance–oriented Building Code.

- A locally focused inspection process and warranty requirements which inhibit adoption of innovations.

- Strong local influences which favour local firms and act as effective non–tariff barriers. By discouraging competition, these influences also discourage innovation.

CHARACTERISTICS OF THE MARKET

With respect to the diffusion process, the characteristics of the Low–Rise Residential Housing market are:

- The relative unimportance of the buyer as a "prescriptor". Besides a few very visible items, such as "Jacuzzis", "oak railings", "skylights" and other such "hot buttons", buyers play a minor role in determining the products and processes used in the construction of houses. The key individuals are the contractor and the sub–tradespeople.

- The relative unimportance of long term or life cycle costs considerations to the buyer (initial price and carrying costs are more important than maintenance and operating costs). This mitigates against higher priced innovations even if they are of higher quality and help, for example, to reduce energy costs.

Isolation, lack of communications, risk avoidance, discontinuity and low levels of formal education are generally reliable indicators of an industry structure with low permeability to innovations. This is confirmed by John Landis among others who, in his study "Why Homebuilders Don't Innovate", came to the conclusion that in order to increase the technological level of the industry, more attention should be focused on the "problem of diffusion of innovations rather than on the promotion of inventions".

THE POLITICAL/INSTITUTIONAL ENVIRONMENT

The present environment can best be understood when put back into an historical perspective. Since World War II the two main actors at the federal level have been CMHC and NRC. In recent years EMR, Industry Associations and Provincial governments have played an increasing role.

CMHC's traditional mandate has been one to promote the construction of residential units. In the process it has played a major role in establishing good building practices and in improving the quality of building materials and components, but the political criterion for measuring success was primarily the one related to number of units built in any given year, rather than to achieving better performance in terms of energy use, air quality or any other similar criterion.

The energy crisis and the UFFI problem profoundly affected the political and institutional environment. EMR, as a result of its mandate in the energy conservation field became a significant player in 1980 through its R2000 program. The R2000 program was the first to focus on performance, it was also innovative in its system approach to buildings and in the type of relationships that it developed with the industry associations (especially the CHBA) and building trades.

The NRC has had a strong presence in the area since 1941 when it developed the National Building Code, but its participation, through the IRC (originally the Division of Building Research) was mainly focussed on developing minimum design requirements in the area of fire safety, structural safety and health.

More recently, the NRC has reversed its traditional reluctance to assume the role of a "certifying" agency and the Canadian Construction Materials Centre (CCMC) has been established. The purpose of the CCMC will be to evaluate new products and processes and encourage innovation through enhanced industry communication. The CCMC may eventually play an important role in the export promotion of Canadian building materials.

DIFFUSION

The Diffusion Process

The diffusion process is the process by which an innovation is introduced into the market place until such innovation, be it a product or a process, becomes used "on a significant scale". As a product may never achieve total market domination (i.e., 100 per cent of all sales for that type or category of products) diffusion, for the purposes of this study will be said to have been achieved when current sales are in the twenty per cent plus range for the relevant target market. The notion of relevant target market is therefore the key in defining success. If the broad definition for countertop material is used, then Corian at two per cent penetration might be considered a failure. If the target market is defined as high–priced custom houses and renovations then the extent of market penetration would probably be within the 20 per cent range making it a product used "on a significant scale".

Communications and Diffusion

Effective communication for the purpose of diffusion requires that information be first given to the prospective adopter by a credible source. The quality of the information and its format are important, but the credibility of the source is the most critical element at this stage. The vertical communications step (so called because it generally goes from the manufacturer to the consumer) is not sufficient to achieve a change of attitude vis–à–vis the product. For this to happen, a second step must take place. The recipient and his peers must have an opportunity to discuss, exchange views, develop opinions and receive peer feedback. The importance of this step being related to the fact that peers are perceived as the highest credibility source available in the LRRCI. Case studies have confirmed that

all effective communications were a combination of vertical communication (advertising, sales presentations, brochures, etc.) and opportunities for discussions at professional association meetings or training sessions. The R–2000 program is the most prominent example of the continued use of these communication strategies.

TYPES OF INNOVATIONS

Innovations can be put on a continuum from fundamental to adaptive and functional.

Fundamental Innovations

All fundamental innovations are not exactly similar, some fulfill a need which was not being satisfied before. A likely example would be air conditioning. Other fundamental innovations do not go as far, but they fulfill a given need in a completely novel way.

When drywall was first introduced it was a complete departure from plaster and lath. To an extent, Heat Recovery Ventilators and Solar Heating are also fundamental innovations.

Adaptive Innovations

Adaptive innovations are those which already exist in one sector of the economy and are being adapted for use in another. Although they may resemble fundamental innovations in the sense that they fulfil a given need in a novel way, they are different from the diffusion point of view because they are already being used successfully in another industry. This tends to reduce considerably, the barriers to adoption.

The introduction of computers into the industry is typically adaptive in nature since computers had been available for a considerable period and since the functions they perform (at least initially) in the Low–Rise Residential Construction Industry are similar to those they have been performing for many other small businesses.

Some innovations such as articulated and telescopic cranes are hard to slot. They tend to fall near the middle of the fundamental to adaptive continuum.

Functional Innovations

Functional innovations are the least disruptive. Functional innovations occur almost naturally in the evolution of a product. A functional innovation is said to occur when an existing product is put to a new but related use in the same industry. For example, Drywall is now available for use in high humidity areas and can also be found pre–wallpapered. These are just two examples of functional innovations.

If we consider insulated sheathing as an extension of non–insulated sheathing, it represents the only apparent functional innovation in the sample of case studies. Articulated cranes and CORIAN, among others cannot be classified as functional innovations because the original innovation was outside the LRRCI.

For purposes of diffusion, it is however more efficient to use a different set of categories, namely:

- "Direct substitutes"
- "Visible Cosmetics" and
- "Invisible innovations".

Perfect direct substitution occurs when the new product maintains all the essential characteristics of the previous product while adding one or more comparative advantages. Adaptive innovations tend to be better "direct substitutes" than fundamental innovations, for example ABS DWV piping is a better direct substitute for iron piping than Drywall is to plaster and lath.

The reason is directly rooted in the difference between the two types of innovations. As a rule, fundamental innovations are "very different" and it takes a while until their characteristics are known and understood and until the perception of risk associated with all that is new and unknown subsides.

The more perfect a direct substitute, the more it reduces or eliminates the problems of complexity, viability and communications (these are important diffusion related characteristics which are dealt with in detail later). It is also more likely to be compatible with current regulations and to achieve faster market acceptance.

"Visible Cosmetics" are items such as Jacuzzis and oak railings which are used by builders to attract buyers. These products are as much fashion items as they are innovations. The most representative example in this study is the CORIAN Case. Diffusion of innovation of visible cosmetics follows the traditional diffusion patterns determined by consumer awareness, interest, evaluation, trial and adoption.

"Invisible Innovations" are not supported by consumer demand and have no immediate or obvious significant comparative advantage in terms of cost, time saving or availability to the builder or tradesperson. Regardless whether they are fundamental or adaptive, builders consider these as strictly cost items without "value added". They are usually unwilling to include them in their basic package because they feel that it would put them at a competitive disadvantage.

At best, builders will agree to include them in the "add–on" list. The most representative examples in this study are HRVs, Active Solar Systems and Air Source Heat Pumps. The important point to note here is that a change in market conditions can improve significantly the prospects for these innovations, but as a rule, the Low–Rise Residential Construction Industry does not easily adopt them.

SUMMARY FIGURE : 1
BARRIERS AND ACCELERATORS TO DIFFUSION

Product *	Relative * Advantage	Compatibility*	Communi- * cability	Complexity*	Trialability*	Risk *	Innovator* Strength	Trade * Resistance	Regulatory * Resistance	Perceived Liability Risk *	Supporting * Innovation	Government * Support	Consumer * Resistance
Drywall (after 1945)	○	○	○	○	○	○	○	●	●		○		●
Aluminum Wiring	○	○	○	○	○	○	○		●				
ABS DWV	○	○	○	○	○	○	○						
CPVC Pipes	●	●		○	●	●	●	●	●	●			●
Pb Pipes	●	●		○	●	●	●	●	●	●			●
HRV's	●	●	●	●	●	●	●	●	●	●		○	
Manufactured Windows	○	○	○	○	○	○	●				○		
Insulated Sheathing	○	○	○	○	○	○	○						
Modular Homes	●	●	○	○	●	●	●	●					●
Telescopic Cranes	○	○	○	○	○	●	●						
Articulated Cranes	○	○	○	○	○	●	●						
Manufactured Chimneys	○	○	○	○	●	○	○	●	●		○		●
Air Source Heat Pump	●	○	●	●	●	●	●					○	
Tool & Equipment Rental	○	○	○	○	○	○	●						
CORIAN	○	○	○	○	○	○	○	●			○		
Active Solar Systems	●	●	●	●	●	●	●	●				○	
UV Poly Film	●	○	○	○	○	●	○	●					
Micro-Computer use by Building Contractors	○	○	●	●	●	○							
The National Building Code	○	○		●			○	●				○	
Materials Approval	○	○		●			○	●				○	
TYVEK	○	○	○	●	○	○	○						●

* Information On This Table Is Only Indicative Please Refer To Case Studies For Specific Details, Especially Where Evaluation Was Involved.

● REPRESENTS A BARRIER TO DIFFUSION

○ REPRESENTS A DIFFUSION ACCELERATOR

BARRIERS AND DIFFUSION ACCELERATORS

As indicated in Summary Figure 1, there are a number of characteristics which affect innovation. The following is a brief discussion of each of those characteristics. It must be noted that these have been stated as separate items for explanation purposes, although, in reality, they are all intertwined. Summary Figure 3 highlights the cumulative effect of barriers and accelerators on the diffusion process itself in terms of probability of success and resulting innovation pace.

Relative Advantage

If an innovation does not yield a cost saving,labour saving or allow for the use of less skilled labour or that of a more abundant type, i.e., time or energy saving, it will not be of interest to the potential user. Adoption of an innovation is not only related to the existence, size and type of advantages, it is also related to how concrete and how immediate the advantages are. In terms of Diffusion Process, the degree of perceived Relative Advantage impacts directly on the economic, social and psychological risk assessment. As such it is the major barrier to diffusion between Innovators and Early Adopters.

Compatibility

A tradesperson is not interested in adopting an innovation which either forces him to change working habits or which threatens his livelihood. A good example is manufactured housing which generates little enthusiasm from those it would displace. Low compatibility is typical of the information picked up by the technical information network (and by the informal peer group information network).

Low compatibility directly affects the risk assessment component of the Diffusion process.

Communicability

In a way, communicability is directly related to relative advantage. If the advantages are easy to explain, they are easier to understand. Tyvek, with its

slogan "windbreaker over a sweater" is a brilliant example of how to overcome a potential drawback of the product, i.e., what does it do, and in this particular case, what is the difference with the vapour barrier and why it should go on the outside.

Complexity

It is a corollary of the previous factor. If an innovation is too complex it is seen as too risky and incompatible. HRVs are seen as complex and this is a barrier to their support by heat and ventilation tradespeople.

Trialability

Trialability is directly related to risk perception. The consumer (or builder) is reluctant to commit to a choice which may involve considerable financial or market, or for that matter plain operating risks. If the prospective adopter is allowed to "try" the product, he is in a position to make a better evaluation of the real risks. As a rule, if the product performs according to expectations this greatly facilitates the process of adoption.

The Sears Roebuck company has built its entire marketing strategy on this element of the diffusion process. Its slogan "satisfaction or your money back" was directly aimed at having consumers try out products at no risk.

Risk

Members of the L.R.R.C.I. have a low tolerance for risk. They will stay away from any innovation which carries a market risk, a competitive risk and especially a financial risk. This is due to their low level of capitalization which does not allow them to use a product before it is well accepted by the market, even if the product has proven itself in another area (e.g., wood preserved foundations) nor if it may increase costs without "adding value" (competitive risk).

The low risk tolerance of the LRRCI is an important element in the explanation of why "direct substitute" and "visible cosmetics" products are adopted while "invisible innovations" are not.

Distributor Strength

If the distributor launching a new product does not have the prestige and the resources, he may not be able to undertake the promotional, advertising and training activities needed and therefore fail to give the push necessary to establish the product on the market. A strong distributor has the staying power necessary to shepherd his product through the various steps of the process.

Trade Resistance

The L.R.R.C.I. is very fragmented and characterized by very low vertical integration and very high sub–contracting. In such an environment, each participant tends to have a very specialized role such as excavation, foundation form, cement, framing, electricians, plumbers, drywallers, roofers, etc. Each operates in a time tested way which minimizes interfacing problems with the other sub–trades and, incidentally, with the municipal inspectors. Any product or process innovation has the potential to upset this carefully balanced situation.

Regulatory Resistance

It used to be linked to product structure, increasingly it is being linked to product performance and to possible secondary, delayed or combined effects.

Plastic pipes are being held back in part because there were delays in approving their use for hot water, and even for cold water when connections are of the "crimped" type (because of flow restriction).

Manufactured chimneys had to prove themselves province by province, town by town before they finally overcame regulatory resistance.

The stagnation of HRV sales is to an extent linked to the fact that installers are, by regulation, responsible for the ventilation balance of the dwelling where an HRV is being installed.

All of the above indicate that regulatory resistance can be a major barrier to diffusion and an important element in determining the pace of diffusion.

Liability

Small builders and sub–trade people do not, as a rule, have a high level of formal education. The cases confirm that word of mouth is their major channel of communication. Information is passed on by the manufacturer's representative or by a distributor, but because of their low credibility this information is first cross–checked in discussion with peers before it is acted upon. Over the years, builders have become more and more concerned about liabilities. The various provincial home warranty plans have done nothing to calm these fears.

The high fear of liabilities is not being checked by the communication network and this is resulting in builders and sub–trades people rejecting innovations for fear that they may lead to unforeseen liabilities down the road. As mentioned in the plastic plumbing case, it leads to the so called "IBM" syndrome. A builder will use the traditional product because, if it fails, he cannot be blamed while he may be if he used a new "untried" product.

Supporting Innovations

Many times, an innovation fails to diffuse because it is held back by a technical problem as was the case with CORIAN, or by drywall before the invention of the tape, drywall screw and ready mixed compound. A supporting innovation, such as cladding or double glazed, sealed panes, can increase the relative advantage of a product and facilitate or speed up its diffusion.

Government Support

Government assistance for R & D, demonstration, training, or sales support is an obvious aid to diffusion since it lowers costs, favours communications, reduces risk and increases relative advantages.

Consumer Resistance

Consumers have only a limited knowledge of the construction process and of what materials are utilized. Nonetheless, over the years, consumers have formed strong opinions about certain products and these opinions have affected the purchasing behaviours of builders and developers who are unwilling to take market risks or to spend time and money in the process of educating the consumer. For example, in the early days Drywall was considered inferior. This perception slowed down Drywall diffusion for many years.

CPVC pipes are being hampered because builders believe that consumers are concerned about the fact that they are a "chlorine" product. To an extent, all "foam" insulating material are suspect because consumers are still concerned about "UFFI".

The best example is perhaps the treated wood foundations which are widely used in some areas but almost non–existent in others because of "consumer resistance".

THE PACE OF INNOVATION

Any classification along a continuum is open to discussion, any ex post factor classification is even more so. The diffusion of innovations literature which spans more than 20 years and hundreds of products is sufficiently robust to support the classifications which have been made below. Nonetheless, these conclusions are being offered as indicative only.

The three figures that follow highlight the influence of innovation type on the pace of diffusion. The first figure, Summary Figure 2, shows the time it took for each innovation studied to diffuse in Canada (and in the world). The second figure, Summary Figure 3, is an attempt to classify innovations along the Fundamental Adaptive/Functional Continuum and across the "Direct Substitute"/"Visible Cosmetic"/"Invisible Innovation" range. It also indicates if diffusion was successful and how long it took to succeed (in Canada).

The third figure, Summary Figure 4, is a summary of the preceding one and it shows that:

- The Direct Substitutes included in the sample had a 100 per cent diffusion success rate. This rate held for all three categories: Fundamental (3 case studies), Adaptive (two case studies), and Functional (one case study). While the low number of case studies in the sample precludes sweeping conclusions, the results, nonetheless suggest an explanatory relationship.

- As expected, there is a continuum in the Canadian pace of innovation, even within a given category. For example, in the case of Direct Substitutes:

  - It took an average of 28.7 years for Fundamental Innovations to diffuse in Canada,
  - It took only 12.8 years for Adaptive Innovations, and
  - Only seven years for functional ones.

  This faster diffusion process tends to support the hypothesis that:

  - the success of an innovation is related to its classification on the Direct Substitute/Visible Cosmetics/Invisible Innovation nominal scale; and

  - the pace of diffusion is related to the classification on the Fundamental/Adaptive/Functional classification.

- As expected, there are no Fundamental/Visible Cosmetics products. To be successfully, "visible cosmetics" products must offer little or no risk. This tends to preclude innovations which by definition have some element of risk. As a rule one would expect Visible Cosmetics to originate from the adaptive or functional areas.

- The Visible Cosmetics/Adaptive products included in the sample (two case studies; CORIAN and Tyvek) have a high diffusion success rate. In fact, if one considers Tyvek as a success (although results are still pending) the rate would be 100 per cent.

- It took CORIAN 13 years to diffuse in the LRRCI from its first introduction (in the institutional market) in Canada. It took only six years from its introduction in the LRRCI to achieve success in its target market.

- The case study sample includes six Invisible Innovations, they have a 0 per cent rate of diffusion success. Some of the products in this category have been on the market for as long as 40 years, most have been available in Canada for 13 years and longer.

SUMMARY FIGURE 2
THE PACE OF INNOVATION

Product (2)	Earliest (1) Marketing Worldwide	Earliest (1) Marketing in Canada	Significant (1) Diffusion in Canada	World Related Pace (1)	Canadian Pace (1)
Drywall	1910	1930's	1960	50y	30y
Aluminum Wiring	1934	1948	1965	31y	17y
ABS DWV	1960	1965	1968	8y	3y
CPVC Pipes	1975	1975	not reached	--	--
Pb Pipes	1972	1975	not reached	--	--
HRV's	--	1976	not reached	--	--
Manufactured Windows	--	1945	1955	--	10y
Insulated Sheathing	--	1980	1987	--	7y
Modular Homes	--	1945	not reached	--	--
Telescopic Cranes	--	1950	1980	--	30y
Articulated Cranes	1945	1955	1985	40y	30y
Manufactured Chimneys	1933	1933	1965	32y	32y
Air Source Heat Pump	--	1970	not reached	--	--
Tool & Equipment Rental	--	1945	1965	--	20y
CORIAN	1972	1974	1987	15y	13y
Active Solar Systems	1960	1975	not reached	--	--
TYVEK	1982	1983	not reached	--	--
Micro-Computer use by Building Contractors	1973	1974	1988	15y	14 y
The National Building Code		1941	1965		24y

(1) All Dates Are Approximated

(2)The CMHC Materials Evaluation and the UV Stabilized Polyethylene vapour barrier cases are Not Included In This Table.

SUMMARY FIGURE 3
INNOVATION TYPOLOGY AND DIFFUSION

PRODUCT	INNOVATION CATEGORY	INNOVATION TYPE	BARRIERS	ACCELERATORS	SUCCESS	WORLD PACE	CANADIAN PACE
MANUFACTURED CHIMNEYS	Direct Sub.	Fundamental	low	medium	Yes	32 y	32 y
DRYWALL	Direct Sub.	Fundamental	low	high	Yes	50 y	30 y
NATIONAL BLDG. CODE	Direct Sub.	Fundamental	low	high	Yes		24 y
							Avg = 28.7 y
TOOL & EQUIPMENT RENTAL	Direct Sub.	Adaptative	low	high	Yes		20 y
ALUMINUM WIRING	Direct Sub.	Adaptative	none	high	Yes	31 y	17 y
MICROCOMPUTERS	Direct Sub.	Adaptative	low	medium	Yes		14 y
MANUFACTURED WINDOWS	Direct Sub.	Adaptative	low	high	Yes	15 y	10 y
ABS DWV PIPES	Direct Sub.	Adaptative	none	high	Yes	8 y	3 y
							Av = 12.8 y
INSULATED SHEATHING	Direct Sub.	Functional	none	high	Yes		7 y
							Av = 7 y
TELESCOPIC CRANES	Direct Sub.	Fund/ Adapt	low	low	Yes		30 y
ARTICULATED CRANES	Direct Sub.	Fund/Adapt	low	low	Yes	40 y	30 y
							Avg=Not aplic.
CORIAN	Visible Cosm.	Adaptative	none	high	Yes	15 y	13 y
TYVEK	Visible Cosm.	Adaptative	low	high	?		
							Avg= 13 y
CPVC PIPES	Invisible Innov	Fundamental	high	low	No		
PB PIPES	Invisible Innov	Fundamental	high	low	No		
HRVS	Invisible Innov	Fundamental	high	low	No		
AIR SOURCE HEAT PUMPS	Invisible Innov	Fundamental	medium	low	No		
ACTIVE SOLAR SYSTEM	Invisible Innov	Fundamental	high	low	No		
MODULAR HOMES	Invisible Innov	Adaptative	high	low	No		

(1) The Data contained in this figure was obtained from Summary Figures 1 and 2, as well as from the case studies.

(2) The " Materials Evaluation " and the " UV Stabilized Poly Film " cases were not included because no Track Record is yet available

SUMMARY FIGURE : 4
INNOVATION TYPOLOGY AND DIFFUSION

SUMMARY TABLE

% RATE OF SUCCESS / AVERAGE PACE of DIFFUSION	Direct Substitutes	Visible Cosmetics	Invisible Innovations
Fundamental Innovations (1)	100 % / (2) 28.7 Years	N.A / N.A	0 % / - 0 -
Adaptive Innovations (1)	100 % / (2) 12.8 Years	50 % / 13 Years	0 % / - 0 -
Functional Innovations (3)	100 % / (3) 7 Years	N.A / N.A	N.A / N.A

(1) Excludes Telescopic and Articulated Cranes which could not be adequately classified
(2) This figure represents the average number of years it took this category of products to achieve successfull diffusion in Canada , as per figure 3
(3) Based on 1 product only
(4) Does not include TYVEK. If TYVEK is considered successfull, figures would be 100 % and 9 Years.

OBSERVATIONS AND CONCLUSIONS ON DIFFUSION OF INNOVATIONS IN THE LRRCI

Given the characteristics of the L.R.R.C.I., and the findings from the case studies, the conclusion is that the L.R.R.C.I. may be slow, but is not significantly slower than other industries. What is important is that Direct Substitutions Innovations do diffuse and that the cases allow the identification of two distinct phases in their diffusion. The first stage is the latent stage or incubation period which could be accelerated. The other is the take–off phase which is already fairly fast.

Based on the analysis of Summary Figures 1, 2, 3, 4 and on observations from the case studies, a number of tentative conclusions can be drawn. Because of the small sample size of case studies these conclusions are presented as working hypothesis which should be submitted to further validation.

It is important to note that the conclusions of this study concur with those made by THORKELSSON ARCHITECTS in their study prepared for the Financial Assistance and Research Branch of the Housing Division of Alberta Municipal Affairs. Namely that:

1. The process by which innovation and technology transfer takes place is not well understood, particularly by the innovators who are involved in it.

2. Innovators are not as skilled as they need to be in assessing and refining their innovation and explaining its full advantages to others whose support would help the innovation's acceptance.

3. There is a general lack of money to develop innovations.

4. The general ignorance of a house buyer about most aspects of residential construction precludes him from being an effective contributor to the trends in housing innovation as it applies to building technology, materials and products.

5. Builders by and large are risk averse and resist incorporating innovations into

their building processes unless there are well proven and demonstrated advantages.

In addition to the above, this study yielded the following:

1. The probability of success of an innovation is directly related to its classification as a Direct Substitute, a Visible Cosmetic or an Invisible Innovation.

2. Direct Substitutes and Visible Cosmetics appear to have a very high rate of success.

3. Where the innovation is not supported by consumer demand and has no immediate or obvious significant comparative advantage to the builder or tradesperson (i.e., it is an "invisible" innovation), it has very little prospect of diffusion success.

4. The pace of diffusion of an innovation is directly related to its classification as a Fundamental innovation, an Adaptive innovation or a Functional one.

5. Functional innovations diffuse fastest, followed by Adaptive innovations and Fundamental ones.

6. The strength of the company launching a product can influence the pace of adoption.

7. The strength of the company launching a product has less influence on the eventual success than the type of innovation involved.

8. Trade resistance can slow down the pace of innovation, but does not appear to determine the eventual probability of success.

9. Trade resistance is mainly based on incompatibility between the proposed innovation and current habits and practices.

10. Sub–trade specialization and reluctance to update other trades is a major factor in trade resistance.
11. Being able to try–out a product is an important diffusion accelerator.

12. Product complexity, or at least perceived product complexity is a barrier to diffusion.

RECOMMENDATIONS

1. Credibility of source, importance of peers, large number of small builders, risk aversion, etc., points to the necessity for government and industry to concentrate on developing communications within the industry and encouraging exchange of information on new products.

2. One excellent opportunity occurs when builders gather in large numbers at their annual convention. The industry should make "technological innovation, new products and techniques" the theme of one of its forthcoming annual conferences.

3. CMHC/Industry Associations should further strengthen the regional/local networks of local builders. The strengthening of these networks could be achieved by encouraging regular meetings/workgroups between CMHC regional/local staff, appropriate staff from NRC/EMR and local builders for the purpose of discussing issues related to recent innovations and other issues of importance.

4. The risk aversion of builders and other LRRCI participants suggests the usefulness of including up to date diffusion related information (who is using what, where, and their experience). This information tabulated by type and size of users, as well as by geographical distribution should be incorporated into NRC's Canadian Construction Information System (CCIS) and in CMHC workshops.

5. Construction Centres should provide excellent vehicles for the transfer of new ideas. Federal government agencies should be in a position to provide advice,

assistance and work with provinces, local building associates, etc. in establishing such centres and ensuring linkage between them.

6. The high level of risk aversion, i.e., the desire not to be first to adopt an innovation, suggests that "demonstration" is an extremely important diffusion accelerator. CMHC should consider initiating a demonstration program in coordination with industry to demonstrate worthwhile innovations in techniques and products.

7. This study demonstrated the relatively unimportant role played by buyers in the diffusion process because of lack of information. The government should take the lead in sensitizing the consumer to the long term implications of his purchase decisions. CMHC Brochures/Seminars for new purchasers and the availability of selected CCIC information to the consumer media and consumer groups would go a long way towards bringing consumers more fully into the diffusion process.

8. Both government and industry should take steps to identify and publicize innovations. CMHC's "job site innovation program" is a step in this direction. Government and industry should consider the production of brochures for each trade, describing new ideas and techniques to improve practice and increase productivity. These could be updated on a regular basis.

9. Given the complexity of the process of technology transfer, it is apparent that efforts to facilitate transfer, to be effective, must adopt a multi-pronged and fully integrated approach. This must take into account education and training, marketing, the interface with other components of the production process, and consideration of codes and standards.